TRANSIMS TRAVELOGUE

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TRANSIMS TRAVELOGUE describes current activities within the TRANSIMS project.

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WHAT IS TRANSIMS?

The TRansportation ANalysis and SIMulation System (TRANSIMS) is one part of the multi-track Travel Model Improvement Program sponsored by the U.S. Department of Transportation, the Environmental Protection Agency, and the Department of Energy. Los Alamos National Laboratory is leading this major effort to develop new, integrated transportation and air quality forecasting procedures necessary to satisfy the Intermodal Surface Transportation Efficiency Act and the Clean Air Act and its amendments.

TRANSIMS is a set of integrated analytical and simulation models and supporting data bases. The TRANSIMS methods deal with individual behavioral units and proceed through several steps to estimate travel. TRANSIMS predicts trips for individual households, residents and vehicles rather than for zonal aggregations of households. TRANSIMS also predicts the movement of individual freight loads. A regional microsimulation executes the generated trips on the transportation network, modeling the individual vehicle interactions and predicting the transportation system performance. Motor vehicle emissions are estimated using traffic information produced by TRANSIMS.

PROJECT APPROACH

We are developing two interim operational capabilities (IOC) to cover the major TRANSIMS components: Household and Commercial Activity Disaggregation, Intermodal Route Planner, Transportation Micro-simulation, and Environment (primarily vehicle emissions). As each IOC is ready and with the collaboration of a selected metropolitan planning organization (MPO), we will complete a specific case study to confirm the IOC features, applicability, and readiness. This approach should provide timely interaction and feedback from the TRANSIMS user community and interim products, capabilities, and applications.

Traffic microsimulation was emphasized in the first IOC, which we tested in a case study in the Dallas-Fort Worth region with the support of the selected MPO, the North Central Texas Council of Governments. The next IOC focuses primarily on the iteration among the Intermodal Route Planner and the Transportation Microsimulation, but also will incorporate iteration with activity demand and the capability for emissions predictions. The supporting case study will be situated in Portland, OR, where we will work with Portland Metro.

DALLAS-FORT WORTH CASE STUDY

We completed the Dallas-Fort Worth case study using the traffic microsimulation IOC. The Dallas-Fort Worth case study demonstrated the ability of the TRANSIMS technology to execute a second-by-second microsimulation for a detailed roadway network including freeways, arterials, and local streets; to feedback link travel times from the microsimulation to the route planner, and to address issues that MPOs typically confront in major investment studies. The study exhibited additional capabilities such as uncertainty analysis, subpopulation and equity analysis, and transportation system reliability analysis.

For demonstration purposes the study focused on a major shopping/business center, the Galleria area, located near the interchange of the Lyndon B. Johnson Freeway (I-635) and the Dallas North Tollway. The case study examined the transportation system performance within the 5-by-5 mile region of interest (ROI) around the interchange.

Because the traffic microsimulation required individual traveler plans, methods were developed to use existing zonal production/ attraction (PA) matrices from the four-step distribution process as the system traveler demand. Only vehicle trips were considered. For each of the region's 800 transportation analysis zones, synthetic traveler activities were distributed randomly to locations (link centers for this study) within the zone. Activity start times were selected statistically from 24-hour distributions of start times according to trip type. This activity demand was varied in the uncertainty analysis, but not in the alternatives assessments.

An interim route planner module produced traveler plans based on minimum travel time for the disaggregated travelers. Initial link travel times were estimated from free flow conditions. After the microsimulation executed the travelers' planned travel, link travel times were updated and a small percentage (5%-20%) of the travel plans were replanned. This iteration between the planner and the microsimulation was repeated until the microsimulation produced reasonable traffic patterns.

We examined two infrastructure alternatives for reducing traffic congestion—an arterial system alternative and a freeway alternative. The arterial system alternative included additional lanes on four major arterials, additional frontage roads to improve continuity and Galleria access, a grade-separated intersection, additional turn bays at several major intersections, and restricted left turns at four entries to arterials. The freeway alternative added another lane to I-635 in both directions through the ROI. We expected the arterial system alternative to benefit primarily travelers to and from the Galleria, and other travelers to some extent. The freeway alternative was intended to benefit all travelers, including the Galleria travelers to the same or a comparable extent.

The primary measures of effectiveness (MOE) used in the analyses were each individual traveler's time of travel and average speed from origin to destination. We grouped the travelers into five-minute intervals according to their trip starting times. With these five-minute groupings, we then could examine the time variation in the MOE statistical distributions during the 5-9 am period.

<u>Uncertainty Analysis</u>

The uncertainty analysis measured how intrinsic uncertainty in the microsimulation, route planner, and activity demand models affected the simulated travelers' MOEs. If these effects were large compared to effects attributable to an infrastructure change, then, on the basis of the simulation results, one would be much less confident that the infrastructure change would make any difference.

All three models included a stochastic component controlled in each instance by a random number generator, requiring a random number seed. A different random number seed created a different random number sequence, which induced a component of model uncertainty. The microsimulation model uncertainty existed in the randomness with which vehicles slowed or changed lanes. The route planner's uncertainty was exhibited by slight variations in departure times, but there was even greater uncertainty in the random selection of trips for replanning. The activity demand modeling uncertainty originated from the random selection of activity start times and their random location at the zones' links' centers, producing uncertainty in the trip origins and destinations.

The maximum median travel time variability arising from the microsimulation model uncertainty was only a couple seconds and occurred right at the peak hour. The planner model uncertainty caused a peak variability in median travel times of a few seconds. The activity demand model uncertainty had the greatest impact on the travelers' median travel times, about 30 seconds difference near the 8:00 peak congestion. When we examined other changes within the case study, such as infrastructure changes, the activity start times and locations were unchanged, and hence the activity demand uncertainty was not a concern. However, the trip plans and microsimulation did change. For these analyses we noted that the planner and microsimulation uncertainties always had less impact than the change caused by the infrastructure.

<u>Equity Analysis</u>

The equity analysis illustrated TRANSIMS's ability to partition the benefits and costs of transportation infrastructure changes among subpopulations of travelers. For this study we partitioned the traveler population into Galleria travelers (those going to and from the Galleria) and non-Galleria travelers. Because we followed individual travelers throughout the simulation, we could determine the benefits to both populations from the infrastructure changes. Indeed both subpopulations benefited from both infrastructure changes, primarily during the peak congestion period from about 7:15 to 8:45. The Galleria travelers median travel time improved by approximately one minute for both infrastructure changes until shortly before 8:00. The arterial benefit continued after that time, but the freeway benefit diminished over the next hour as the peak congestion abated.

The non-Galleria travelers received a 30-second improvement in median travel time from both infrastructure changes during the peak period. They benefited slightly more from the freeway changes before 8:00 and slightly more from the arterial changes after 8:00.

<u>Reliability Analysis</u>

The reliability analysis addressed the issue of variability in day-to-day travel times. In other words, how much can a traveler depend on his travel time being the same from one day to the next. For this study we selected a new starting time for each traveler from a uniform distribution within five minutes of the original starting time. After executing these new trips we calculated the absolute difference in travel times for each traveler. For the base infrastructure the median day-to-day travel time difference was less than 30 seconds, but 25% of the travelers incurred more than a 75-second variation around 8:00, and 5% saw their travel times change by more than four minutes. Although we did not do the analysis, the TRANSIMS approach allows us to identify those travelers who experienced the most variability in their travel times. Thus, we could determine what these travelers have in common (origins, destinations, traveled links) that would cause their variability to be significantly greater than the average traveler.

In addition, the reliability analysis indicated that travel times were more reliable for both infrastructure changes than for the base infrastructure and that the arterial change had more reliable travel times than the freeway change. At 8:00 the arterial change improved the reliability by 10 seconds for the 25% of the travelers suffering from the worst reliability and by almost 2 minutes for the worst 5%. The freeway change didn't provide quite as good reliability improvements prior to 8:00 and reliability diminished even further thereafter.

Case Study Conclusions

Overall, the case study demonstrated the soundness of the TRANSIMS approach for transportation planning. The iteration between the planner and microsimulation, while requiring further research and development, provided feedback of executed travel times to adapt travelers' day-to-day travel plans for traffic congestion. In addition to traditional MOEs such as median travel time and median speed, the case study evoked new measures such as transportation system reliability, time varying distributions of traveler travel times and speeds, and the transportation system's impact on an individual traveler or subpopulations of travelers.

The completed case study report will be released by the Department of Transportation in the coming months.

PACKAGING

We are packaging the interim operational capability used for the Dallas-Fort Worth case study for release to selected sites for testing and research feedback. This package includes an updated microsimulation with improved driving logic and enhanced portability. In addition, the package includes a plan preprocessor to select individual plans from a plan set, a plan viewer and a microsimulation output viewer, a network editor, and a user interface It does not include the case study interim route planner because further research into planner methods is ongoing and, even though it was required for the case study, this simple planner was not intended for the original IOC-1.

The package includes the networks used in the case study and the final plan sets that were executed in the ROI; however, their usage will be restricted to addressing research questions. Furthermore, the package includes calibration networks and plan sets for microsimulation calibration against four typical situations that limit network capacity. User documentation, including installation procedures, accompanies the package and data.

The package is designed to run on either multi-processor Sun workstations or a local area network of Sun workstations. Use of third party software licenses is limited in the package.

Package users will be required to sign a license agreement. Information on package availability can be obtained from Fred Ducca, Federal Highway Administration.

We also are completing the packaging of the Synthetic Population Generator, which creates a baseline synthetic population of households. The individuals in the households are used as travelers in the activity-based TRANSIMS model. The 1990 census data used to develop the baseline population includes the Census Standard Tape File 3 (STF-3A) and the Public Use Microdata Sample (PUMS). We use the STF-3A summary tables and the corresponding sample from the PUMS to create the five-dimensional multiway table of probabilities for each combination of the five demographic variables for both family and nonfamily households.

We create distinct households for each census tract or block group area (we currently use block groups). The procedure involves three stages. First, for the block group in question, we group the census summary tables from STF-3A and the corresponding PUMS sample by family and non-family households. Second, for each household type, we construct a multiway table of the demographics available from STF-3A. We use iterative proportional fitting to generate the multiway tables. It is easy to implement and it converges in a few iterations. Third, we create households by random selection (according to the probabilities in the constructed multiway table) of similar households in the PUMS sample.

Potential users of the Synthetic Population Generator also will be required to sign a license agreement. Information on package availability can be obtained from Fred Ducca, Federal Highway Administration.

PLANNER METHODS

We are exploring methods for formal language constrained shortest paths on a hierarchical network for use in the TRANSIMS Intermodal Route Planner. In these methods we create separate networks for each transportation mode. For instance, we may have separate networks for automobiles, buses, walking, bicycles, light rail, etc. The perceived or real costs of a link's traversal are assigned to each link in these networks. Where a mode change can occur, we have a transfer link between the two different mode networks. This transfer link also has the associated intermodal transfer cost whether it be time, money, and other attributes or qualities that may influence a traveler's mode decision.

Each link on a mode network also is assigned a label unique to the mode. For instance, the automobile network may be labeled 'c'; the bus network, 'b'; the walk network, 'w'; the rail network, 't'; etc. Then we establish a formal language that describes the sequence of labeled links, identifying mode choices, for paths through the network. For example, an all-walk path is described by w^+, where w^+ denotes a sequence of walk links. A walk to the bus stop, followed by riding the bus to a downtown stop, and then completing the trip with a walk to the work place is denoted by $w^+b^+w^+$. Some paths are not allowed—for example, $b^+c^+b^+c^+$ would be an unusual path for a commuter, requiring having an automobile stashed, and requiring jumping from bus to car and car to bus.

Thus we establish a set of allowed sequences within the formal language and assign probabilities for using each sequence. Initially the probabilities may be uniform. They may be conditional on the household demographics; for example, if a car is unavailable, the chances of c^+ being in the sequence are small. In our research, we have developed fast-running algorithms that find minimum cost paths having these labeled sequences through the multi-modal network and thus generate trip plans for travelers. After the microsimulation has executed the trips, in addition to updating the link costs, the information fed back to the planner can adjust the probabilities for picking the mode sequences. Mode splits thus emerge from the iteration between the planner and the micro-simulation. The technique has the advantage that when a forecasted transportation system or policy is simulated, the mode split depends on the system and policies.

We also are investigating path finding algorithms that find the closest destination from among several destinations when a traveler has several alternative locations for accomplishing his activities. Thus we are researching efficient interfaces between the route planner and the activity generation module, focusing on efficient ways to encode mode preferences and choices that depend on the order of performed activities. We are examining efficient algorithms for time-dependent, mode choice constraint shortest paths and routes, route problems with time window constraints and related scheduling and routing problems.

IOC-2 PLANNING

The next TRANSIMS Interim Operational Capability focuses primarily on the iteration among the Intermodal Route Planner and the Transportation Microsimulation, but also will incorporate iteration with activity demand and the capability for emissions predictions. The supporting case study will be situated in Portland, OR, where we will work with Portland Metro.

We have begun initial planning for the case study that will demonstrate the capabilities of the second IOC. Although our plans are not yet firm, we are considering a study that involves activity demand forecast, intermodal trip plans, and microsimulation for all of the Portland Metro planning region. We also are considering a forecast scenario for a future year. We expect to include the usual travel modes (auto, bus, light rail, walk, and bicycle) in the study, and a high occupancy vehicle analysis is receiving strong consideration. Trucks and freight also will be represented. The environmental analysis will involve emissions only, not air quality.

Portland Metro has begun generation of a detailed network for the base year transportation system. We have revised the TRANSIMS network representation to accommodate multi-mode transportation. In the previous section, we reported our ongoing efforts in intermodal planner research. We also have begun extending our microsimulation methods to bus and truck behavior. We contracted with the National Institute of Statistical Sciences to adapt their activity forecasting methods for implementation within the TRANSIMS framework, and we are investigating an alternative activity forecasting method with Portland Metro.

FURTHER INFORMATION

For further information about the TRANSIMS program, please contact:

Dr. LaRon L. Smith
Los Alamos National Laboratory
Mail Stop F606
PO Box 1663
Los Alamos, New Mexico 87545

Phone: 505-665-1286
Fax: 505-665-5249
E-mail: llsmith@lanl.gov